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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant: Eric Plante
Serial No.: 10/622,009
Filed: July 17, 2003
Title: PROCESSING SCENE OBJECTS

Examiner: Peter Pappas
Group Art Unit: 2628
Docket: G&C 30566.336-US-01

CERTIFICATE OF MAILING OR TRANSMISSION UNDER 37 CFR 1.8

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By: 
Name: Jason S. Feldmar

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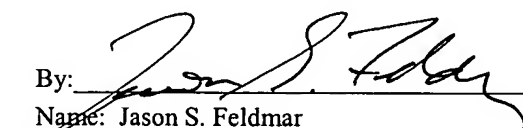
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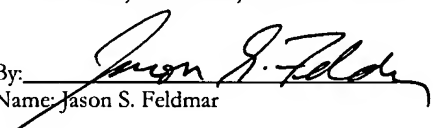


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Dear Sir:

Please place the following Certified Priority Document into the file of the above-identified patent application, as follows:

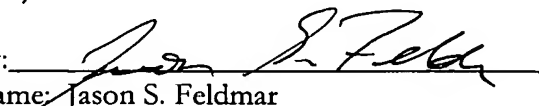
UNITED KINGDOM, Application No. 0216839.1, Filed July 19, 2002

Respectfully submitted,

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G&C 30566.336-US-01



For Innovation

The Patent Office
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I, the undersigned, being an officer duly authorised in accordance with Section 74(1) and (4) of the Deregulation and Contracting Out Act 1994, to sign and issue certificates on behalf of the Comptroller-General, hereby certify that annexed hereto is a true copy of the documents as originally filed in connection with the patent application identified therein together with the Statement of inventorship and of right to grant of a Patent (Form 7/77), which was subsequently filed.

I also certify that the attached copy of the request for grant of a Patent (Form 1/77) bears an amendment, effected by this office, following a request by the applicant and agreed to by the Comptroller-General.

In accordance with the Patents (Companies Re-registration) Rules 1982, if a company named in this certificate and any accompanying documents has re-registered under the Companies Act 1980 with the same name as that with which it was registered immediately before re-registration save for the substitution as, or inclusion as, the last part of the name of the words "public limited company" or their equivalents in Welsh, references to the name of the company in this certificate and any accompanying documents shall be treated as references to the name with which it is so re-registered.

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1/77

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1. Your reference

2034-P585-GB

2. Patent

0216839.1

NEW 19 JUL 2002

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each applicant (underline all surnames)AUTODESK CANADA INC
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Patents ADP number (if you know it)

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4. Title of the invention

PROCESSING SCENE OBJECTS

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Patents ADP number

0114 275 2400

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6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and (if you know it) the or each application number
- | Country | Priority application number (if you know it) | Date of filing (day/month/year) |
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9. Enter the number of sheets for any of the following items you are filing with this form. Do not count copies of the same document.

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29 /

Claim(s)

07 /

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01 /

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NONE

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Statement of inventorship and right to grant of a patent (Patents Form 7/77)

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Request for preliminary examination and search (Patents Form 9/77)

ONE(1) /

Request for substantive examination (Patents Form 10/77)

NONE

Any other documents (Please specify)

11.

I/We request the grant of a patent on the basis of this application.

Signature

Date Friday, 19 July 2002

12. Name and daytime telephone number of person to contact in the United Kingdom

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P07/7700 0.00-0216839.1

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Statement of inventorship and of
right to grant of a patentThe Patent Office
Concept House
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1. Your reference

20940585-QB

2. Patent application number

02.18.839.1

3. Full name, address and postcode of the or of
each applicant (underline all surnames)AUTODESK CANADA INC
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4. Title of the invention

PROCESSING SCENE OBJECTS

5. State how the applicant(s) derived the right
from the inventor(s) to be granted a patentThe Applicant derived the right to the
invention by virtue of a contract of
employment6. How many, if any, additional Patents Forms
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one(1)

7.

I/We believe that the person(s) named over the page (and on any extra copies of this form)
is/are the inventor(s) of the invention which the above patent application relates to.

Signature

Date Tuesday, 18 November 2003

8. Name and daytime telephone number of
person to contact in the United KingdomRALPH ATKINSON CPA
0114 275 2400

Patents Form 7/77

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Enter the full names, address and postcodes of the
inventors in the boxes and underline the surnames

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Patents ADP number:

8754673001

Patents ADP number:

Patents ADP number:

Patents ADP number:

DUPLICATE

1

Processing Scene Objects

Background of the Invention

1. Field of the Invention

5 The present invention relates to generating image data as the
blending of a plurality of renders of an object along a motion path overtime.

2. Description of the Related Art

10 Advances in the field of digital signal processing have allowed many
new developments to be effected in video and film post-production. Many
sophisticated image modifications and special effects have become widely
accepted as part of post-production procedures.

15 Often, post-production techniques are used to generate additional
image data to be composited within frames of original video or film footage,
either because said additional image data cannot be realistically committed to
movie or video film, for instance if the movie script requires an actor to jump
over a mile-wide gap, or because it does not exist, for instance if the movie
script requires photo-realistic alien spaceships.

20 The degree of realism conveyed by such image data is traditionally
paramount in order to immerse an audience within the narrative, and
techniques are known with which to motion-blur the additional image data
when such data portrays moving objects or actors. Motion is usually a
function of the position of an object changing in each frame of a sequence of
frame. Displaying such a sequence at the appropriate speed, for instance 24

frames per second for movie films, provides the audience with the illusion of movement. Motion-blurring techniques are used to enhance this illusion, and are especially relevant when the object in question is moving at a fast pace. Motion blurring traditionally involves specifying a shutter length indicative of the number of frames to use to evaluate the motion of an object thereon, and a number of samples which defines how many snapshots are taken of each of said frames, whereby said samples are subsequently blended and the output of said blending operation is an output frame showing said object with motion-blur.

A problem however exists in motion-blurring techniques according to the known prior art, in that additional objects as described above have to be independently motion-blurred if artistic considerations or the movie script requires discrete degrees of motion-blurring for each additional object in the same frame, for instance if two alien spaceships are flying at different speeds, because said motion-blurring techniques according to the known prior art require the shutter length and the number of samples be configured for the entire scene or output frame. This may generate visible artefacts which are highly undesirable to convey the required degree of realism.

Moreover, the independent motion-blurring of said additional objects is very resource-intensive, because a separate output frame may be required for each of said motion-blurred objects, to be composited at a later stage with the original movie or video footage.

A need therefore exists for an improved motion-blurring technique, which is less resource-intensive and allows for generating any additional

objects in a frame at individual degrees of motion-blurring.

Brief Summary of the Invention

According to a first aspect of the present invention, there is provided
5 an apparatus for generating image data comprising memory means
configured to store said image data as a volume comprising at least one
object and at least one viewport, memory means configured to store motion
data for said object, configuration data for said viewport and instructions,
and processing means configured by said instructions to perform the steps
10 of defining a motion path for said object within said volume in reply to user
input; translating said object along said path over a user-specified period of
time; rendering said object through said viewport at portions of said user-
specified time period; and blending the resulting plurality of rendered
objects to generate said image data.

15 According to another aspect of the present invention, there is provided
a method of generating image data defined as a volume comprising at least
one object and at least one viewport, wherein said method includes motion
data for said object and configuration data for said viewport, and said
method comprises the steps of defining a motion path for said object within
20 said volume in reply to user input; translating said object along said path
over a user-specified period of time; rendering said object through said
viewport at portions of said user-specified time period; and blending the
resulting plurality of rendered objects to generate said image data.

Brief Description of the Several Views of the Drawings

Figure 1 shows an image processing system operated by an image editor;

5 *Figure 2* details the hardware components of the image processing system of *Figure 1* in further detail;

Figure 3 shows motion blur processing to generate image frames according to the known prior art;

10 *Figure 4* details the operational steps according to which a user operates the image processing system of *Figures 1* and *2* according to the invention;

Figure 5 shows the contents of the main memory shown in *Figure 2* after the step of loading instructions and data shown in *Figure 4*;

Figure 6 provides an example of a scene structure including scene data as shown in *Figure 5*;

15 *Figure 7* further details the image data shown in *Figures 5* and *6* as a plurality of objects, including a viewport, within a three-dimensional volume;

Figure 8 illustrates the graphical user interface of the application shown in *Figures 4* and *5*, including a graphical representation of the scene structure and scene data shown in *Figures 6* and *7*;

20 *Figure 9* details the processing steps involved for editing scene data shown in *Figures 4* to *7* as scene objects shown in *Figure 8*;

Figure 10 graphically illustrates the step of equipping an object in the scene of *Figures 6* to *8* with a motion path as shown in *Figure 9*;

Figure 11 details the processing steps according to which image data

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is rendered as shown in *Figure 4*;

Figure 12 further details the processing steps according to which samples are processed to generate motion blur shown in *Figure 11*;

Figure 13 shows the objects shown in *Figure 10* sampled and stacked
5 in the memory as shown in *Figure 12*;

Figure 14 details the processing steps according to which the samples shown in *Figure 13* are processed to generate output frame image data;

Figure 15 graphically illustrates the rendering of the objects shown in *Figures 7, 8, 10 and 13* and subsequent blending thereof according to the
10 present invention to generate a complete scene.

Written Description of the Best Mode for Carrying Out the Invention

Figure 1

An image processing system such as a post-production station is
15 illustrated in *Figure 1*. An image editor **101** controls an image processing environment formed by a processing system **102**, a video monitor **103** and a RAID **104**, by means of a keyboard **105**, and a stylus-operated graphics tablet or a mouse **106**. The processing system **102**, such as an Octane™
produced by Silicon Graphics Inc., supplies image signals to the video
20 display unit **103**. Moving image data is stored on the redundant array of inexpensive discs (RAID) **104**. The RAID is configured in such a way as to store a large volume of data, and to supply this data at a high bandwidth, when required, to the processing system **102**. The processing system shown in *Figure 1* is optimal for the purpose of processing image and other

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high bandwidth data. In such a system, the instructions for controlling the processing system are complex. The invention relates to any computer system where processing instructions are of significant complexity.

Instructions controlling the processing system 102 may be installed
5 from a physical medium such as a CD-ROM or DVD-ROM 107, or over a network 108 from a network server 109, including the Internet 110 accessed therefrom. These instructions enable the processing system 102 to interpret user commands from the keyboard 105 and the mouse or graphics tablet 106, such that image data, and other data, may be viewed,
10 edited and processed.

Figure 2

The processing system 102 shown in *Figure 1* is detailed in *Figure 2*.
The processing system comprises two central processing units 201 and
15 202 operating in parallel. Each of these processors is a MIPS R11000 manufactured by MIPS Technologies Incorporated, of Mountain View, California. Each of these processors 201 and 202 has a dedicated secondary cache memory 203 and 204 that facilitate per-CPU storage of frequently used instructions and data. Each CPU 201 and 202 further
20 includes separate primary instruction and data cache memory circuits on the same chip, thereby facilitating a further level of processing improvement. A memory controller 205 provides a common connection between the processors 201 and 202 and a main memory 206. The main memory 206 comprises two gigabytes of dynamic RAM.

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The memory controller 205 further facilitates connectivity between the aforementioned components of the processing system 102 and a high bandwidth non-blocking crossbar switch 207. The switch makes it possible to provide a direct high capacity connection between any of several
5 attached circuits. These include a graphics card 208. The graphics card 208 generally receives instructions from the processors 201 and 202 to perform various types of graphical image rendering processes, resulting in images, clips and scenes being rendered in real time on the monitor 103. A high bandwidth SCSI bridge 209 provides an interface to the RAID 104,
10 and also, optionally, to a digital tape device, for use as backup.

A second SCSI bridge 210 facilitates connection between the crossbar switch 207 and a DVD/CDROM drive 211. The DVD drive provides a convenient way of receiving large quantities of instructions and data, and is typically used to install instructions for the processing system
15 102 onto a hard disk drive 212. Once installed, instructions located on the hard disk drive 212 may be fetched into main memory 206 and then executed by the processors 201 and 202. An input output (I/O) bridge 213 provides an interface for the mouse or graphics tablet 106 and the keyboard 105, through which the user is able to provide instructions to the
20 processing system 102.

Figure 3

Techniques are known to generate motion blur for an object or talent to be composited in a clip of frames at a later stage, in order to convincingly

portray the illusion of movement at speed of said object or talent in the final composited clip. Generating motion blur for an imaginary object according to the known prior art is shown in *Figure 3*.

In order to generate a clip portraying a spaceship 301 travelling at speed, said spaceship 301 is first modelled in a three-dimensional volume 302 with vertices, which eventually define polygons to which textures and a variety of other characteristics may be applied. The volume, or scene 302, is preferably equipped with a viewport 303, the purpose of which is to define a view frustum, the origin of which functions as a camera to render a two-dimensional image of the three-dimensional volume 302 and object 301 therein as seen therethrough.

In order to generate the aforementioned motion blur for spaceship 301 according to the known prior art, it is necessary to render a plurality of images frames 304, 305, wherein either spaceship 301 is manually translated within volume 302 after image frame 304 is rendered such that image frame 305 portrays spaceship 301 at a different location, or the position and/or orientation of viewport 303 is altered after image frame 304 is rendered so as to similarly obtain an image frame 305 within which spaceship 301 has moved.

Upon obtaining the two distinct image frames 304, 305, a composite image frame 306 portraying spaceship 301 with motion blur 307 is obtained by sampling each of said frames 304, 305 a number of times. The number of frames sampled which, in this example is two, is known to those skilled in the art as the shutter length, or the sample window size. In the example

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according to the prior art described above, five samples 308 to 312 are taken with a shutter length of two frames 304, 305.

The samples 308 to 312 are subsequently blended, whereby the two first samples 308, 309 of image frame 304 carry less weight in the five sample average than the three samples 310 to 312 of image frame 305, such that the latter position of spaceship 301 within image frame 305 is better defined in composited image frame 306 than the previous position of said spaceship 301 within image frame 304, shown as a blur 307.

10 **Figure 4**

The processing steps according to which the image processing system 102 of Figure 1 generates image data according to the invention are further detailed in Figure 4.

15 At step 401, the image processing system 102 is switched on. At step 402, the instructions according to the present invention and the data said instructions configure CPUs 201, 202 to process are loaded from hard disk drive 212, DVD ROM 107, network server 109 or the internet 110, such that said CPUs 201, 202 may start processing said instructions and data at step 403.

20 At step 404, a scene is selected which, according to the present invention, comprises a structure defined as a hierarchy of data processing nodes and a plurality of types of data to be processed therewith.

The processing of said scene data according to said scene structure generates at least one object, for instance spaceship 301, within a scene

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comparable to three-dimensional volume 302 configured with at least one viewport comparable to viewport 303, whereby the results of the editing of any of the data defining said object 301, scene 302 or viewport 303 may be rendered as a frame or a clip of frames at step 406.

5 At step 407, a question is asked as to whether the scene data of another scene should be edited for subsequent rendering. If the question asked at step 407 is answered positively, control is returned to step 404, whereby the editor 101 may select a different scene structure.

10 Alternatively, the scene data rendered at step 406 as edited at step 405 is acceptable for the intended purpose of editor 101, whereby the processing of the instructions according to the invention started at step 403 may now be stopped at step 408 and, eventually, the image processing system 102 switched on at step 401 may eventually be switched off at step 409.

15

Figure 5

The contents of the main memory 206 subsequently to the instructions and data loading of step 402 are further detailed in Figure 5.

20 An operating system is shown at 501, which comprises a reduced set of instructions for CPUs 201 and 202, the purpose of which is to provide image processing system 102 with basic functionality. Examples of basic functions include access to and management of files stored on hard disk drive 212, or DVD/CD ROM drive 211, network connectivity with frame store 104, server 109 and the internet 110, interpretation and processing of

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the input from keyboard 105 and graphic tablet or mouse 106 and graphical data or binary data output. In the example, the operating system is IRIX™ provided by Silicone Graphics Inc, but it will be apparent to those skilled in the art that the instructions according to the present invention may be easily adapted to function with different other known operating systems, such as Windows™ provided by the Microsoft Corporation of Redmond, California or LINUX which is freely distributed.

An application is shown at 502 which comprises the instructions loaded at step 402, which enables the image processing system 102 to perform processing steps 404 to 407 according to the present invention within a specific graphical user interface displayed on VDU 103. A scene structure is shown at 503 and scene data is shown at 504, which comprises various sets of user input-dependent data and user input-independent data according to which the application shown at 502 generates image data.

Scene structure 503 comprises a plurality of node types 505, each of which provides a specific functionality in the overall task of rendering a scene according to step 406. Said node types 505 are structured according to a hierarchy 506, which may preferably but not necessarily take the form of a database, the purpose of which is to reference the order in which various node types 505 process scene data 504. Scene structure 503 also includes at least one motion blur configuration file 507 according to the invention, the purpose and functionality of which will be further described hereinafter.

A number of examples of scene data 504 are provided for illustrative

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purposes only and it will be readily apparent to those skilled in the art that the subset described is here limited only for the purpose of clarity. Said scene data 504 may include image frames 508 acquired from framestore 104, audio files 509 such as musical score or voice acting for the scene structure selected at step 404. Said scene data 504 may also include pre-designed three-dimensional models 510, such as spaceship 301, and a variety of textures 511 to apply to said models 510. In the example, scene data 504 includes lightmaps 512, the purpose of which is to reduce the computational overhead of CPUs 201, 202 when rendering the scene with artificial light sources. Scene data 504 finally include three-dimensional location references 513, the purpose of which is to reference the position of the scene objects edited at step 405 within the three-dimensional volume of the scene.

15 **Figure 6**

A simplified example of a scene, or process tree, is shown in *Figure 6* as the scene structure 503 and scene data 504 loaded into memory 206 at step 402.

Process trees generally consist of sequentially-linked processing nodes, each of which specifies a particular processing task required in order to eventually achieve an output 601, under the form of a composited frame or a sequence of composited frames. Traditionally, an output scene 601 will comprise both image data and audio data. Accordingly, the composited scene will thus require the output from an image-keying node

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602 and the output of a sound mixing node 603. The image-keying node 602 calls on a plurality of further processing nodes to obtain all of the input data it requires to generate the desired image data. In the example, the desired output image data includes a plurality of frames within which a three-dimensional computer-generated spaceship object 301 is composited within a background consisting of a clip of frames 508 portraying a ship at sea.

The image-keying node 602 therefore initially requires a viewport rendering node 604 to define a frustum and characteristics thereof within the three-dimensional scene, through which a two-dimensional rendering of three-dimensional objects within a scene may take place. The image-keying node 602 subsequently requires the sequence of frames 508 from frame node 605, each frame of which is processed by a colour-correction processing node 606 and a motion tracking processing node 607, such that the composited three-dimensional spaceship object 301 generated by three-dimensional modelling node 608, to which is applied a texture 511 by the texturing node 609 and appropriate lightmaps 512 by processing node 610 and which is also motion-tracked by processing node 607, is seamlessly composited within the colour corrected sequence of frames 508.

In so far as the lighting of spaceship 301 is concerned, the image keying processing node 602 also requires the output of a spotlight generated by an artificial light processing node 611 within the scene to interact with the lightmaps 512 of spaceship 301, wherein said artificial light

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is colour-corrected by a colour-correction processing node 612 providing a functionality similar to the functionality of colour-correction processing node 606. A filter object is preferably generated by a light filtering processing node 613 to prevent the artificial light of said spotlight from altering the colour characteristics of the frames 508 within the scene.

In the preferred embodiment of the present invention, all of the data generated by the above described nodes may be visualised as distinct three-dimensional objects within a scene defined as a three-dimensional volume configured with Cartesian x, y and z co-ordinates, whereby motion tracking processing node 607 processes the x, y and z co-ordinates of each of said objects. The image-keying processing node 602 subsequently overlays said three-dimensional objects as viewed through the frustum generated by node 604.

Figure 7

The scene data 504 generated as three-dimensional objects by scene structure 503 described in Figure 6 are shown within a scene defined as a three-dimensional volume in Figure 7.

The textured and lightmap-configured spaceship model 301 is shown within scene 302 in relation to the viewport 303 generated by processing node 604. Said viewport is configured with a view frustum 701 and a focal length 702, which jointly define the two-dimensional plane 703 corresponding to the required image output data generated by output processing node 601. Said two-dimensional plane 703 may simply be

15

thought of as the image frame that would be committed to film, were viewport 303 a conventional camera filming three-dimensional objects within scene 302. Said two-dimensional plane 703 will thus be hereinafter referred to as a rendering window.

5

The clip of frames 508 generated by node 605 is shown as a two-dimensional plane 704 equipped with x, y and z co-ordinate within volume 302, wherein the area of said plane 704 is defined by the resolution in pixels or lines of the image frames 508. Said plane 704 is known to those skilled in the art as a billboard and, depending upon whether the functionality of window 704 allows the entire clip of frames 508 to be played therein, may also be known as a player.

10

15

In the example, volume 302 also includes a spotlight object 705 generated by artificial light node 611 and a filter 706 generated by node 613. Said filter 706 is preferably positioned by motion-tracking node 607 between spotlight 705 and player 704 in order to refract artificial light cast by said spotlight 705 within scene 302 to light spaceship 301 and thus prevent said artificial light from distorting the colour component values of frames 508 within player 704.

20

In the example still, the clip of image frames 508 portrays a ship 707 at sea, wherein said image frames were shot with a camera aboard a different ship. Consequently, the combined motions of the ship 707 and the camera aboard said other ship arising from random sea surface movements result in the level 708 of the sea to alter substantially over the entire duration of the clip of frames 508, whereby ship 707 in effect rises

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and falls along a vertical path within player 704.

Image editor 101 wishes to remove this vertical motion in the composited output clip, effectively tracking a fixed portion of the frame in each frame of the clip of frames 508. However, image editor 101 also wishes to composite spaceship 301 as moving at speed towards a position 709 over said ship 707, which is stationary, in each of said frames 508. A problem therefore exists in that spaceship 301 requires a degree of motion blur to realistically convey the impression of said movement at speed, whilst the ship 707 requires no motion blurring at all, because it is stationary.

With reference to the known prior art described in *Figure 3*, conventional compositing techniques would require image processing system 102 to generate a first clip of frames portraying spaceship 301 moving towards position 709 with motion blurring, the total number of frames of which equals the total number of frames of the clip of frames 508. A second output clip should then be generated as portraying stationary ship 707 with a stable sea level 708, for instance with processing the clip of frames 508 with the "stabiliser with roll" disclosed in United States patent No 5,786,824 assigned to the present applicant. The required result would be achieved by keying the first output clip portraying spaceship 301 moving at speed and the second output clip portraying a stabilised, stationary ship 707.

According to the present invention, however, the above required output clip is generated by means of defining respective motion paths for both spaceship 301 and player 704 within scene 302, respectively

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translating said spaceship 301 and player 704 along said paths over a period of time equivalent to the duration of clip frames 508, rendering spaceship 301 and player 704 at portions of said period of time, which is also known to those skilled in the art as sampling, and blending the
5 resulting plurality of samples in order to generate an output image frame or an output clip of image frames.

Figure 8

The graphical user interface (GUI) of the application 502 is shown in
10 *Figure 8*, including a graphical representation of the scene structure 503 and scene data 504 shown in *Figures 5* and *6* and further described in *Figure 7*.

The GUI 801 of image processing application 502 is preferably divided into a plurality of functional areas, most of which are user-operable.

15 A first area 802 displays scene structure 503 as three-dimensional scene 302. Said scene 302 is preferably displayed with including scene data 504 graphically depicted as scene objects 301, 303 and 701 to 708.

A cursor 803 is displayed which is user operable by means of mouse or graphic tablet 106 and may be positioned by image editor 101 over any
20 portion of GUI 801 to select a variety of functions or tasks within said plurality of functional areas. Thus, within scene display area 802, cursor 803 may be used to select a particular object, for instance spaceship 301, whereby a second user operable area 804 conveys data properties, parameters and/or values specifically pertaining to said selected object.

18

Preferably, second object information display area 804 includes an object identifier portion 805, an object location portion 806 and an object properties portion 807. Portions 805 and 806 of second display area 804 are updated according to which object cursor 803 selects within scene 302 and portion 807 may be subsequently interacted therewith by means of said cursor 803 to edit any of the selected object's properties.

A third display area 808 comprises conventional user-operable clip navigation widgets allowing image editor 101 to respectively rewind, reverse play, pause, stop, play or fast-forward the sequential order of image frames generated from scene 302 by means of rendering window 703. Alternatively, said navigation widgets 808 also provide the same functionality as described above for player 704 if said player is selected as a scene object by means of cursor 803. A counter area 809 is provided in close proximity to the clip navigation widget 808, which is divided into hours, minutes, seconds and frames, such that the aforementioned navigation by means of navigation widgets 808 may be carried out with precision and provide a valid point of reference to image editor 101.

A fourth display area 810 provides a conventional bar of menus operable by means of cursor 803, which provide a variety of functions and processes, for instance with which to load or store image data, further configure the size and contents of display areas 802, 804 and 808 or, eventually, stop processing the instructions according to the invention according to step 409.

Figure 9

The processing step 405 according to which scene data 504 is edited as scene objects shown in *Figures 7 and 8* is further described in *Figure 9*.

5

At step 901, the required output clip length is set. Said length may be understood as the number of output image frames node 602 should render through rendering window 703 in order to generate a complete sequence of frames defining a clip and, in the example, said output clip length is equivalent to either the number of frames 508 of the clip shown as player 704 or, alternatively, the number of frames required to portray spaceship 301 moving at speed to position 709 within scene 302.

10

15

Upon specifying the number of frames to output, a first object such as spaceship 301 is selected in the scene 302, for instance by means of cursor 803, at step 902. A path may subsequently be defined for said selected object within said scene 302 at step 903, for instance by selecting the "path" property of said object within object's properties portion 807.

20

In the preferred embodiment of the present invention, said path is linear and comprises a directional vector, the origin which is defined by the x, y and z co-ordinates of the object selected at step 902 and the extremity of which is defined by the x, y and z co-ordinates of said object subsequently to image editor 101 dragging said object 301 to position 709, for instance with using cursor 803 in a "click and drag" configuration, which is well known to those skilled in the art. In an alternative embodiment of the present invention, however, said path comprises a spline-based curve, for

20

instance to impart a "bobbing" motion to spaceship 301. In yet another alternative embodiment of the present invention, said path is defined as a function, for instance the tracking function disclosed in United States Patent No. 5,786,624 referenced thereabove, wherein said function itself
5 generates a linear or spline-based movement vector.

The path configuration input at step 903 is subsequently stored at step 904 as three-dimensional locations 510, specifically for the object selected at step 902. At step 905, the shutter length specifically relating to the selected object is input. A question is subsequently asked at step 906,
10 as to whether a path should be defined for another object in scene 302. If the question asked at step 906 is answered positively, control is returned to step 902, whereby said next object may be selected and a respective path defined and stored. Alternatively, if the question of step 906 is answered negatively, a sample number is input for the scene as a whole.

15 According to the known prior art, and with reference to Figure 3, shutter length and the number of samples are traditionally specified for the entire scene. Specifying the shutter length and number of samples for the entire scene 302 as described in Figures 7 and 8 according to said prior art would result in generating appropriate motion blurring for spaceship 301,
20 but would also generate motion blurring for ship 707 which, in the example, is undesirable. According to the present invention, shutter length is input for each object in scene 302 independently of the total number of samples required for the scene, whereby it is thus possible to generate a two-dimensional image frame within which each of said plurality of objects is

21

rendered with its own degree of motion blurring such that, in the example, the motion blurring of ship 707 within the original clip of frames 508 is removed whilst appropriate motion blurring is convincingly provided for spaceship 301.

5

Figure 10

The processing step 903 of equipping an object in scene 302 of *Figures 7 and 8* with a motion path is graphically illustrated in *Figure 10*.

With reference to the description of step 903, image editor 101 first selects spaceship object 301 with cursor 803 and drags it within scene 302 to location 709, whereby a linear directional vector 1001 is defined with an origin, the x, y and z co-ordinates of which are obtained from the location of said object 301 before interaction therewith, and an extremity 709, the x, y and z co-ordinates of which within scene 302 are derived from the location to which the cursor 803 releases spaceship 301 after dragging.

15

Preferably, spaceship 301 is selected according to step 902, whereby cursor 803 subsequently selects the path property of said object within portion 807 such that application 502 initiates the vector origin and continually reads the input data of mouse or graphic tablet 106, e.g. cursor 803, to define the length and orientation of said vector within scene 302.

20

Similarly, user 101 selects the player 704 as a next object in scene 302 according to step 902, again selecting the path property of said player within updated portion 807 but specifies said path as a tracking function as opposed to a directional vector. Image editor 101 may subsequently select

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a two-dimensional x, y portion 1002 of the image frame area within player 704, whereby said portion will be tracked in each subsequent frame in said frame display area of said player 704 by means of calculating a movement vector, the inverse of which will be applied to player object 704 such that the x, y portion 1002 remains stable in relation to the two-dimensional rendering window 703.

According to the present invention, individual motion paths may therefore be defined for a number n of objects representing scene data within scene 302, whereby each of said distinct motion paths may be linear, non-linear or the result of an object processing function, in relation to said rendering window 703.

Figure 11

The processing steps according to which image data edited as scene objects is rendered at rendering step 406 are further detailed in Figure 11.

At step 1101, a frame counter is initialised with the number of frames defined by the output clip length configured at step 901 and the first frame of the output clip or output image frame is selected for rendering.

At step 1102, the number of samples input at step 907 are processed in order to generate the image data required to create or remove the respective degree of motion blurring for each of the objects in scene 302 to be rendered as viewed through rendering window 703. Upon generating the required image data as samples of picture screen element,

also known as pixels, each of which having Red (R), Green (G) and Blue (B) colour component values, said samples are processed in order to generate the target pixels defining the output image data, i.e. the output frame, at step 1103.

5 At step 1104, the output frame generated at step 1103 is subtracted from the number of frames initialised in the counter at step 1101, whereby a question is asked as to whether all frames of the required output clip have been rendered. If the question of 1104 is answered negatively, control is returned to step 1101, whereby the next output frame is selected for
10 rendering according to steps 1102 and 1103 and the counter further decreased at step 1104 until such time as question 1104 is answered positively, whereby all of the required output image data has been rendered.

15 **Figure 12**

The processing steps according to which samples are processed at step 1102 in order to generate image data to create motion blur are further detailed in *Figure 12*.

20 At step 1201, application 502 reads the motion blur configuration files 507 of each object in scene 302, to derive the maximum shutter length input for anyone of said objects and set said maximum shutter length as the total number of "unblurred" frames to render for sampling and subsequent processing in order to generate the output frame selected at step 1101. At step 1202, the first frame of said total number of "unblurred" frames is

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rendered and sampled, e.g. the RGB colour component values of each pixel of said frame are read by application 502 such that they may be stacked in memory 206 at the next step 1203.

At step 1204, a question is asked as to whether another "unblurred" frame should be sampled and, if said question is answered affirmatively, the respective x, y and z co-ordinates of each object within scene 302 are interpolated along the respective motion paths of said objects at step 1205, such that the next frame to be sampled may be rendered with the scene objects at interpolated positions at step 1206. Control is subsequently returned to step 1202, whereby said next rendered frame is sampled and said sample is stacked in memory 206 at step 1203.

The question of step 1204 is eventually answered negatively, signifying that all of the required samples of "unblurred" frames have been obtained and may now be processed in order to generate the target pixels.

Figure 13

A graphical representation of the sampling and stacking of processing steps 1202, 1203 as well as the rendering step 1206 is provided in Figure 13.

In the example, it was previously explained that ship 707 should have no motion blurring whatsoever whereas spaceship 301 does require motion blurring to convey the impression of movement at speed. Moreover, in the preferred embodiment of the present invention, only a tracked portion of player 704 is required for the final output image data.

25

Consequently, image editor 101 specifies a shutter length of one frame for player object 704, whereby regardless of the number of additional "unblurred" frames to be rendered according to the frame total of step 1201, the x, y and z position of said player object 704 will not be interpolated and thus said object will appear immobile regardless of the number of samples taken and stacked according to steps 1202 and 1203. Conversely, image editor 101 specifies a shutter length of two frames for spaceship object 301, such that the number of samples specified for the scene at step 907 is equally divided between said two "unblurred" frames in the case of uniform sampling or, alternatively, more samples are taken of one "unblurred" frame than the other in the case of weighed sampling. Both concepts of uniform sampling and weighed sampling will be familiar to those skilled in the art and, for the purpose of clarity, only uniform sampling will be hereinafter described in the present description.

In the example, six samples should be taken and stacked to generate each output image frame and appropriate input is received according to step 907, thus three samples of each of the two "unblurred" frames shall be taken and stacked according to steps 1202, 1203.

In accordance with the description of the present invention, a first "unblurred" frame 1301 is thus generated, the size i.e. resolution of which is defined by tracked portion 1002 of player object 704 and spaceship object 301, both of which are respectively at the origin of their respective motion paths 1001, 1002. Three sample 1302, 1303 and 1304 are taken of said first frame 1301, whereby question 1204 is answered positively and, in

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accordance with the above description, only the position of spaceship objects 301 is interpolated to position 1305 along directional vector 1001 to generate a second "unblurred" frame 1306, three samples 1307, 1308 and 1309 of which are subsequently taken.

5 The stacking of the six samples 1302 to 1304 and 1307 to 1309 is figuratively represented at 1310 and may be thought of as the superimposition of said six samples, the sum total of the colour component values of each corresponding pixel of which is divided by the total number of samples to provide a single image frame comprising the target pixels.

10 **Figure 14**

The processing steps according to which application 502 processes the samples stacked according to step 1203 to generate output frame image data 1310 are further detailed in Figure 14.

15 At step 1401, the first target pixel of the output image frame 1310 is selected, the respective red, green and blue colour component values of which equal the average of the respective red, green and blue colour component values of the pixels having the same two-dimensional co-ordinates in all of the samples stacked.

20 In order to generate said average, each sample is recursively selected at step 1402 such that the pixel therein having x, y co-ordinates equivalent to the x, y co-ordinates of the selected target pixel of step 1401 may be selected at step 1403 and its respective colour component values added at step 1404. At step 1405, a first question is asked as to whether all

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of the samples have been traversed and processed, thus providing total colour component values which may be subsequently divided by the total number of samples traversed at step 1406 to obtain the final RGB colour component value of the target pixels selected at step 1401, if the question of step 1405 is answered positively.

Alternatively, if the question of step 1405 is answered negatively, the next sample is selected at step 1402, traversed to identify the corresponding pixel at step 1403, the RGB values of which are added according to step 1404. Having obtained final RGB colour component values for the target pixel currently selected at step 1401, a second question is asked at step 1407 as to whether all of the target pixels defining the target image frame have been processed, such that the next output image frame may be generated for the final output clip. If the question of step 1407 is answered negatively, control returns to step 1401, whereby the next pixel of the target image frame is selected and its final RGB colour component values calculated according to step 1402 to 1406.

Question 1407 is eventually answered positively, whereby an output image frame is generated which includes a plurality of objects, each of which having its own degree of motion blurring.

Figure 15

The rendering of objects in scene 302 at step 406 according to the present invention is shown in *Figure 15* in order to generate a complete scene comprising a clip of a plurality of output image frames.

For the purpose of clarity, only three output image frames 1501, 1502 and 1503 are shown from an output clip including potentially hundreds or even thousands of image frames generated according to the present invention. Image data defining image frame 1501 is generated according to the processors described in *Figure 13*, wherein motion blurring 1504 is generated by blending image frames 1301 and 1306 according to the processing steps described in *Figure 14*.

The resolution of frame 1501 is derived from the resolution of the tracked portion 1002 of player 704 and includes spaceship 301. As the sampling and stacking processes of steps 1202 to 1206 are carried out to generate the entire clip, the position of spaceship 301 is regularly interpolated along its directional vector, e.g. motion path 1001. However, the tracking function invoked to stabilise player portion 1002 eventually generates a directional vector 1505, the inverse 1506 of which is applied to the entire player object 704 such that ship 707 remains stabilised in output image frame 1502, whilst object 301 is still rendered with motion blur 1504.

Similarly, the tracking function eventually generates another, different directional vector 1507, the inverse of which is yet again applied to the entire player object 704 to achieve the same result in output image frame 1503 as the result described in output image frame 1502.

A method is therefore provided for generating image data 1501 to 1503 define as a volume 302 comprising at least one object 301 and at least one viewport 303, wherein a motion path 1001 is defined for said object 301, the object 301 is translated along said motion path 1001 over a

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period of time specified at 901, said object 301 is rendered (1301, 1306)
through said viewport 303 at sampling portions 1302, 1303, 1304, 1307,
1308 and 1309 and the resulting plurality of renders (1301, 1306) are
blended (1310) to generate said image data 1501.

5

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Claims:

1. Apparatus for generating image data comprising memory means configured to store said image data as a volume comprising at least one object and at least one viewport, memory means configured to store motion data for said object, configuration data for said viewport and instructions, and processing means configured by said instructions to perform the steps of

defining said motion data as a motion path for said object within said volume in reply to user input;

translating said object along said path over a user-specified period of time;

rendering said object through said viewport at portions of said user-specified time period; and

blending the resulting plurality of rendered objects to generate said image data.

2. Apparatus according to claim 1, wherein said volume comprises a plurality of objects.

3. Apparatus according to claim 2, wherein motion paths are respectively defined for each of said objects, said objects are translated

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and rendered at said portions of said user-specified time period and blended to generate said image data.

4. Apparatus according to any claims 1 to 3, wherein said motion
5 path is a directional vector, a definition of which is any of a group
comprising a linear vector, a spline-based vector or a motion data
processing function.

5. Apparatus according to claim 4, wherein said motion data
10 processing function is the tracking of a portion of an object.

6. Apparatus according to any of claims 1 to 5, wherein said
configuration data for said viewport comprises a view frustum and a focal
length.
15

7. Apparatus according to any of claims 1 to 6, wherein said
translating step further includes the step of interpolating the position of said
object along said motion path.

8. Apparatus according to any of claims 1 to 7, wherein said
20 user-specified period of time is a number of frames.

9. Apparatus according to claim any of claims 1 to 8, wherein said portions of said user-specified period of time are samples.

5 10. Apparatus according to any of claims 1 to 9, wherein said : blending step generates motion blurring for said object in said image data.

11. A method for generating image data comprising said image
data as a volume including at least one object and at least one viewport,
10 wherein said method comprises the steps of
defining a motion path for said object within said volume in reply to
user input;
translating said object along said path over a user-specified period of
time;
15 rendering said object through said viewport at portions of said user-
specified time period; and
blending the resulting plurality of rendered objects to generate said
image data.

20 12. A method according to claim 11, wherein said volume
comprises a plurality of objects.

13. A method according to claim 12, wherein motion paths are respectively defined for each of said objects, said objects are translated and rendered at said portions of said user-specified time period and
5 blended to generate said image data.

14. A method according to any claims 11 to 13, wherein said motion path is a directional vector, a definition of which is any of a group comprising a linear vector, a spline-based vector or a motion data
10 processing function.

15. A method according to claim 14, wherein said motion data processing function is the tracking of a portion of an object.

16. A method according to any of claims 11 to 15, wherein said configuration data for said viewport comprises a view frustum and a focal
15 length.

17. A method according to any of claims 11 to 16, wherein said
20 translating step further includes the step of interpolating the position of said object along said motion path.

18. A method according to any of claims 11 to 17, wherein said user-specified period of time is a number of frames.

5 19. A method according to claim any of claims 11 to 18, wherein said portions of said user-specified period of time are samples.

20. A method according to any of claims 11 to 19, wherein said blending step generates motion blurring for said object in said image data.

10 21. A computer readable medium having computer readable instructions executable by a computer, such that said computer performs the steps of:

defining said image data as a volume including at least one object

15 and at least one viewport;

defining a motion path for said object within said volume in reply to user input;

translating said object along said path over a user-specified period of time;

20 rendering said object through said viewport at portions of said user-specified time period; and

blending the resulting plurality of rendered objects to generate said

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image data.

22. A computer readable medium according to claim 21, wherein said volume comprises a plurality of objects.

5

23. A computer readable medium according to claim 22, wherein motion paths are respectively defined for each of said objects, said objects are translated and rendered at said portions of said user-specified time period and blended to generate said image data.

10

24. A computer readable medium according to any claims 21 to 23, wherein said motion path is a directional vector, a definition of which is any of a group comprising a linear vector, a spline-based vector or a motion data processing function.

15

25. A computer readable medium according to any of claims 21 to 24, wherein said translating step further includes the step of interpolating the position of said object along said motion path.

20

26. A computer readable medium according to any of claims 21 to 25, wherein said blending step generates motion blurring for said object in said image data.

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27. A computer system programmed to generate image data,
including memory means configured to store said image data as a volume
comprising at least one object and at least one viewport, memory means
5 configured to store motion data for said object, configuration data for said
viewport and instructions, and processing means configured by said
instructions to perform the steps of

defining said motion data as a motion path for said object within said
volume in reply to user input;

10 translating said object along said path over a user-specified period of
time;

rendering said object through said viewport at portions of said user-
specified time period; and

blending the resulting plurality of rendered objects to generate said
15 image data.

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Abstract of the Disclosure

PROCESSING SCENE OBJECTS

A method is provided for generating image data 1310 defined as a
5 : volume 302 comprising at least one object 301 and at least one viewport
303, wherein a motion path 1001 is defined for said object 301, the object
301 is translated (1205) along said motion path 1001 over a period of user-
specified time (901), said object 301 is rendered (1301, 1306) through said
viewport 303 at sampling portions (1302, 1303, 1304, 1307, 1308, 1309) of
10 said user-specified time and the resulting plurality of renders (1301, 1306)
are blended (1310) to generate said image data 1310.

(Figure 7)

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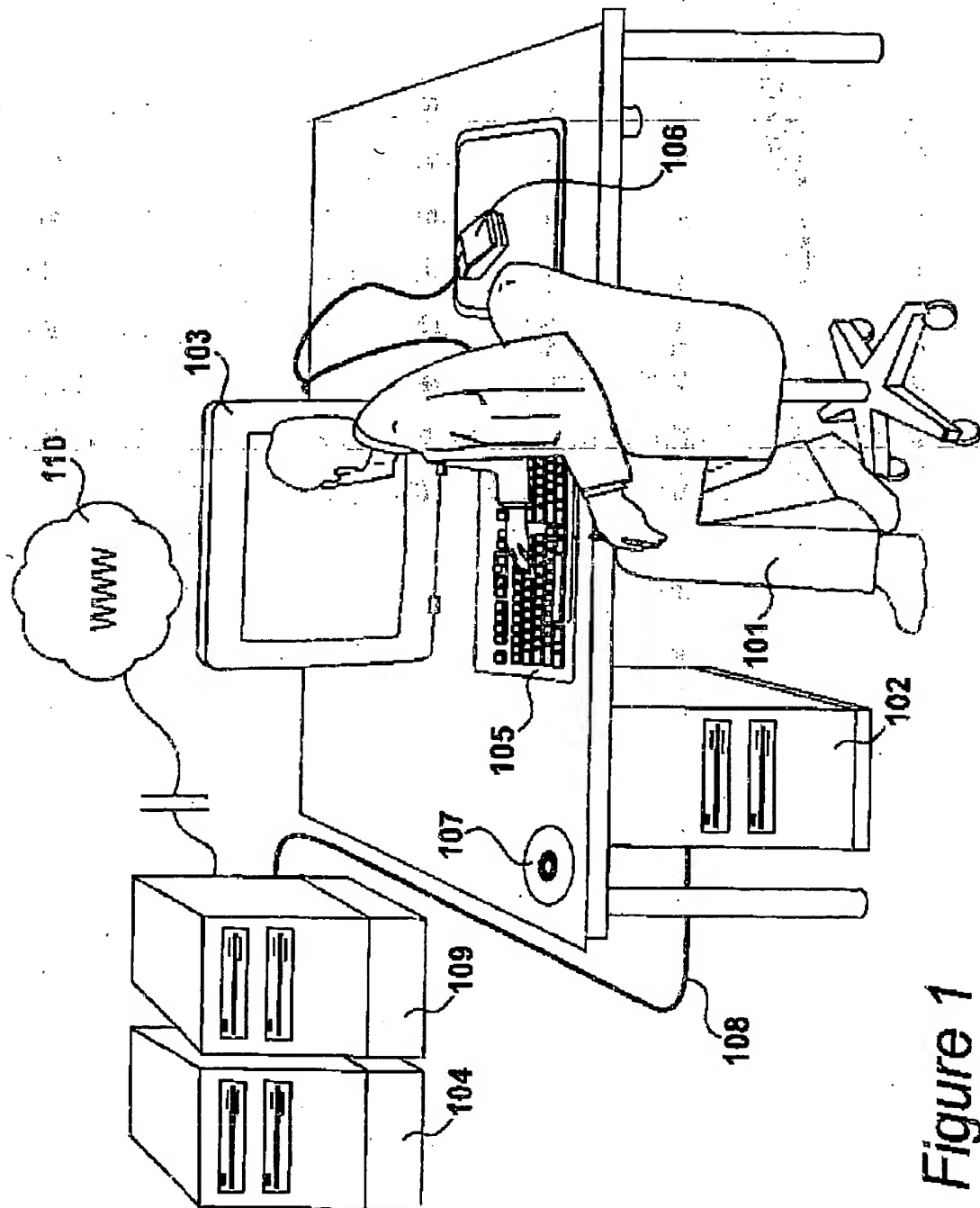


Figure 1

2034-P585-GB

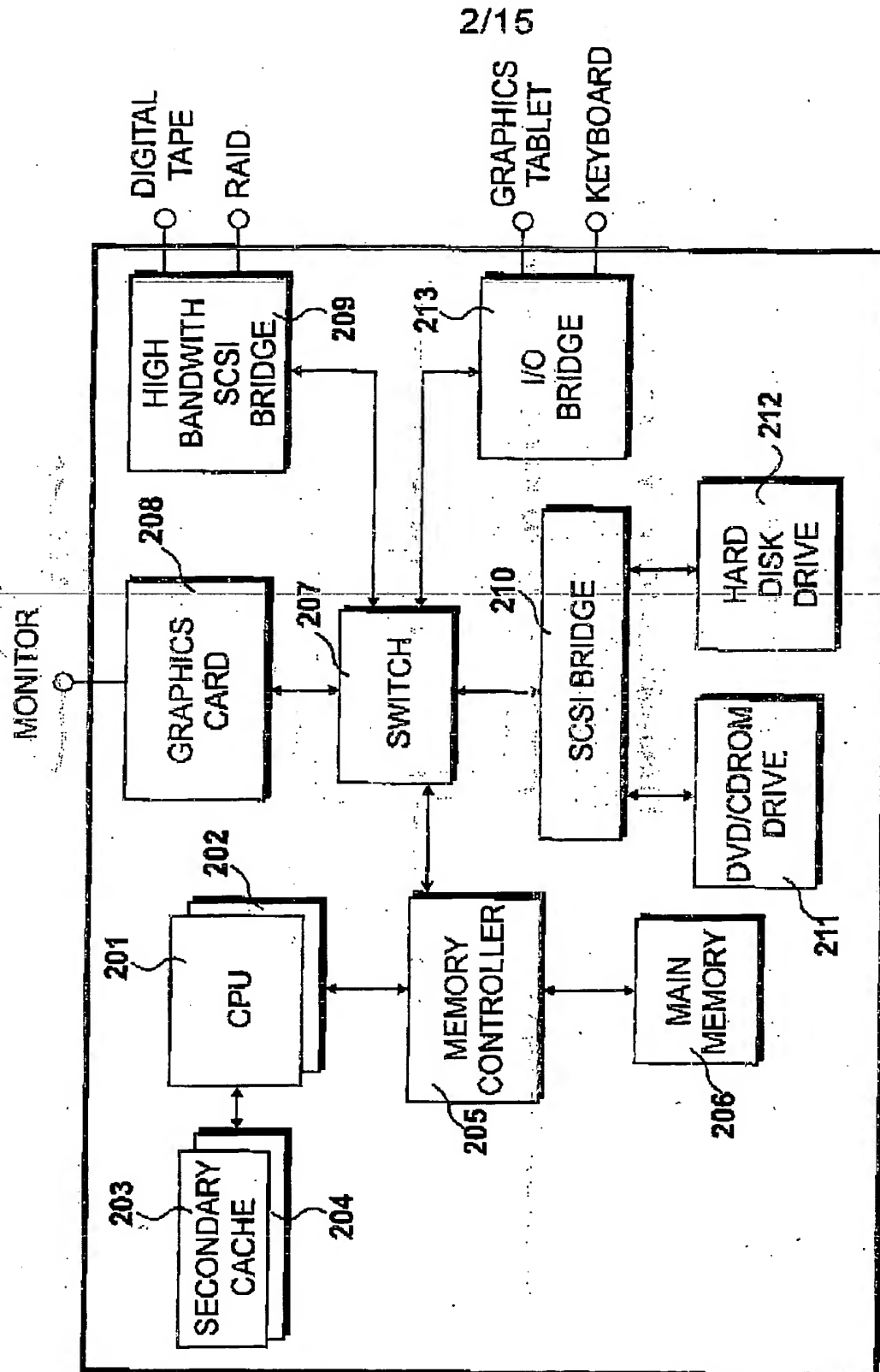


Figure 2

2034-P585-G8

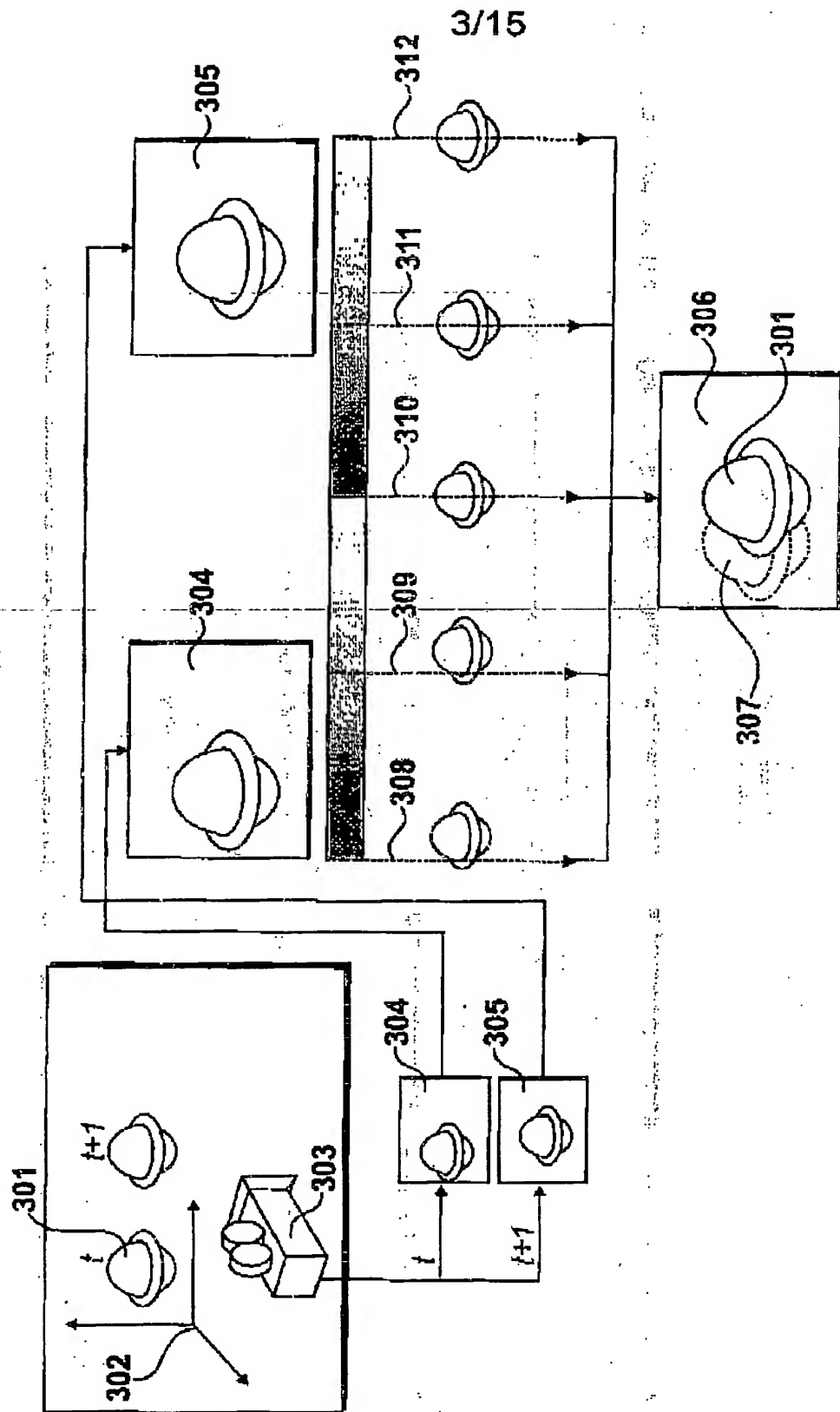
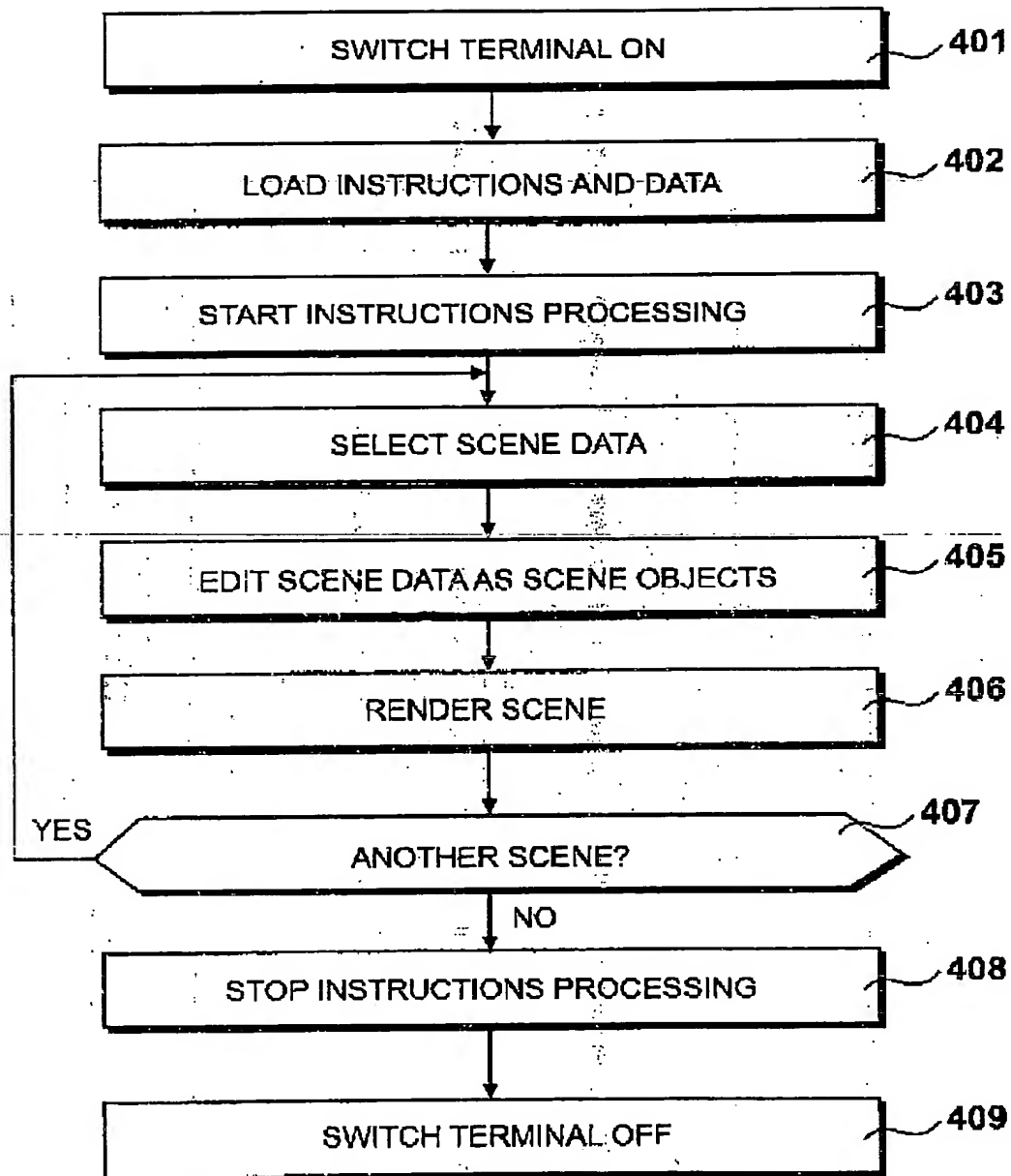


Figure 3

[PRIOR ART]

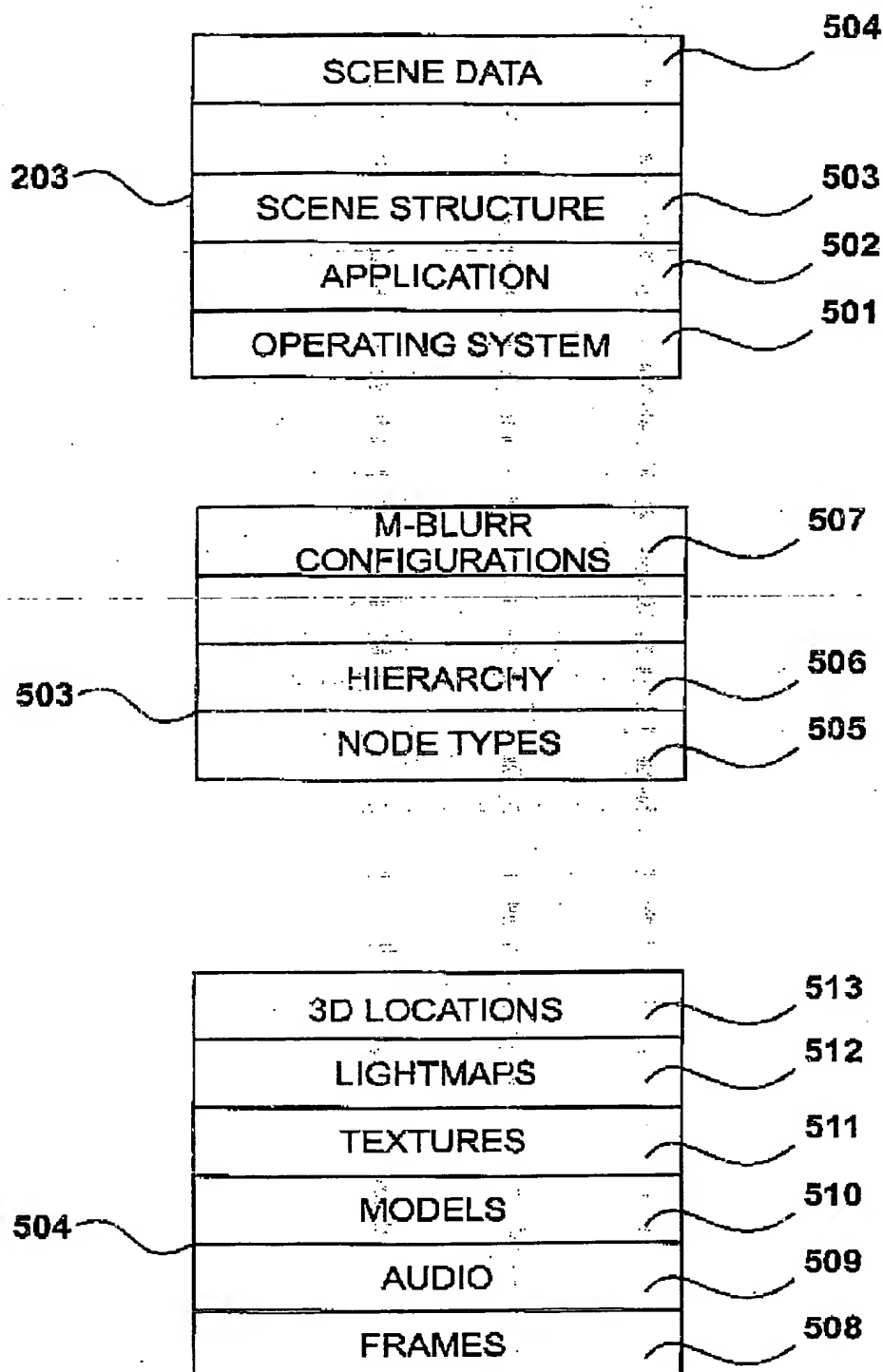
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*Figure 4*

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*Figure 5*

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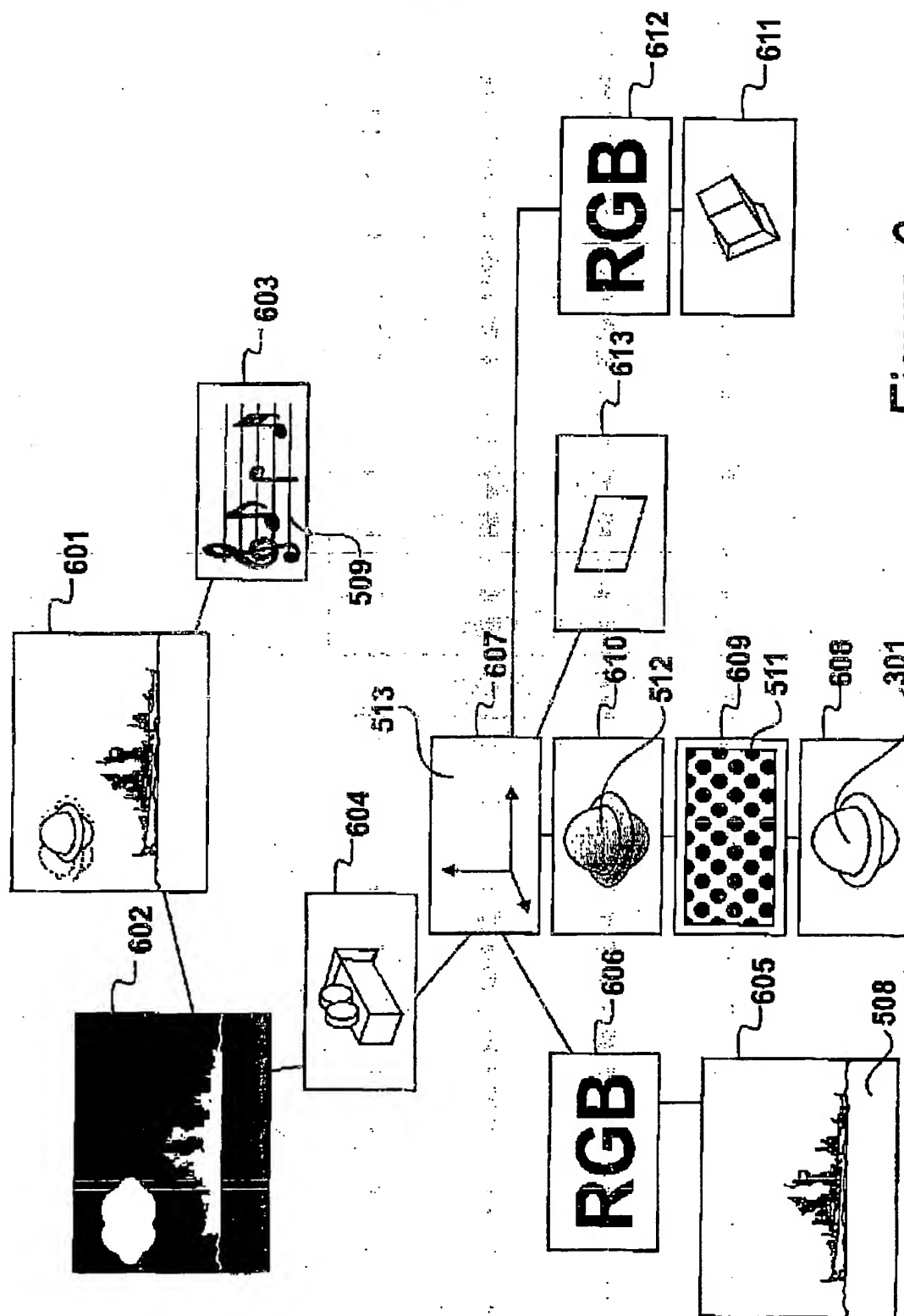


Figure 6

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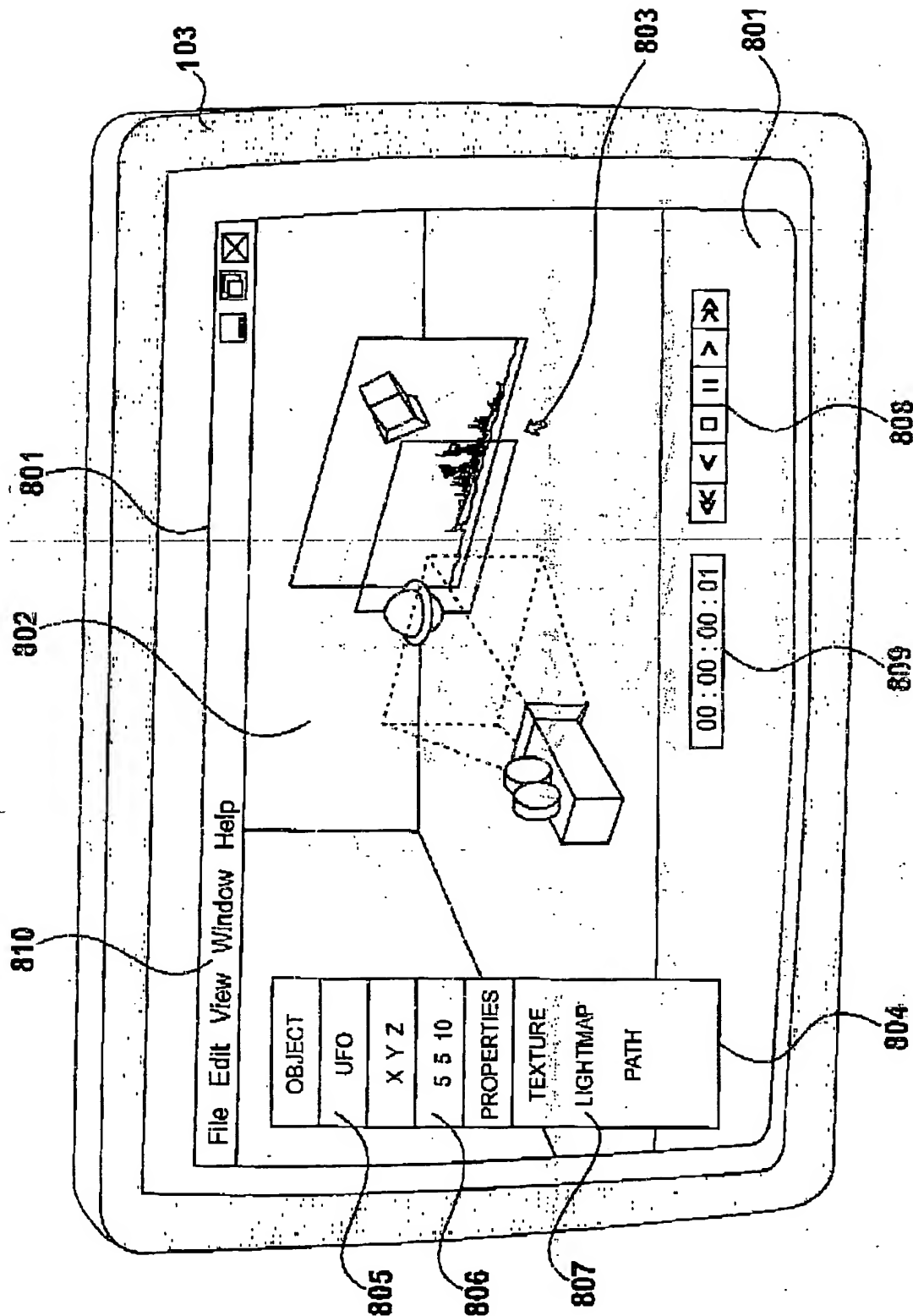
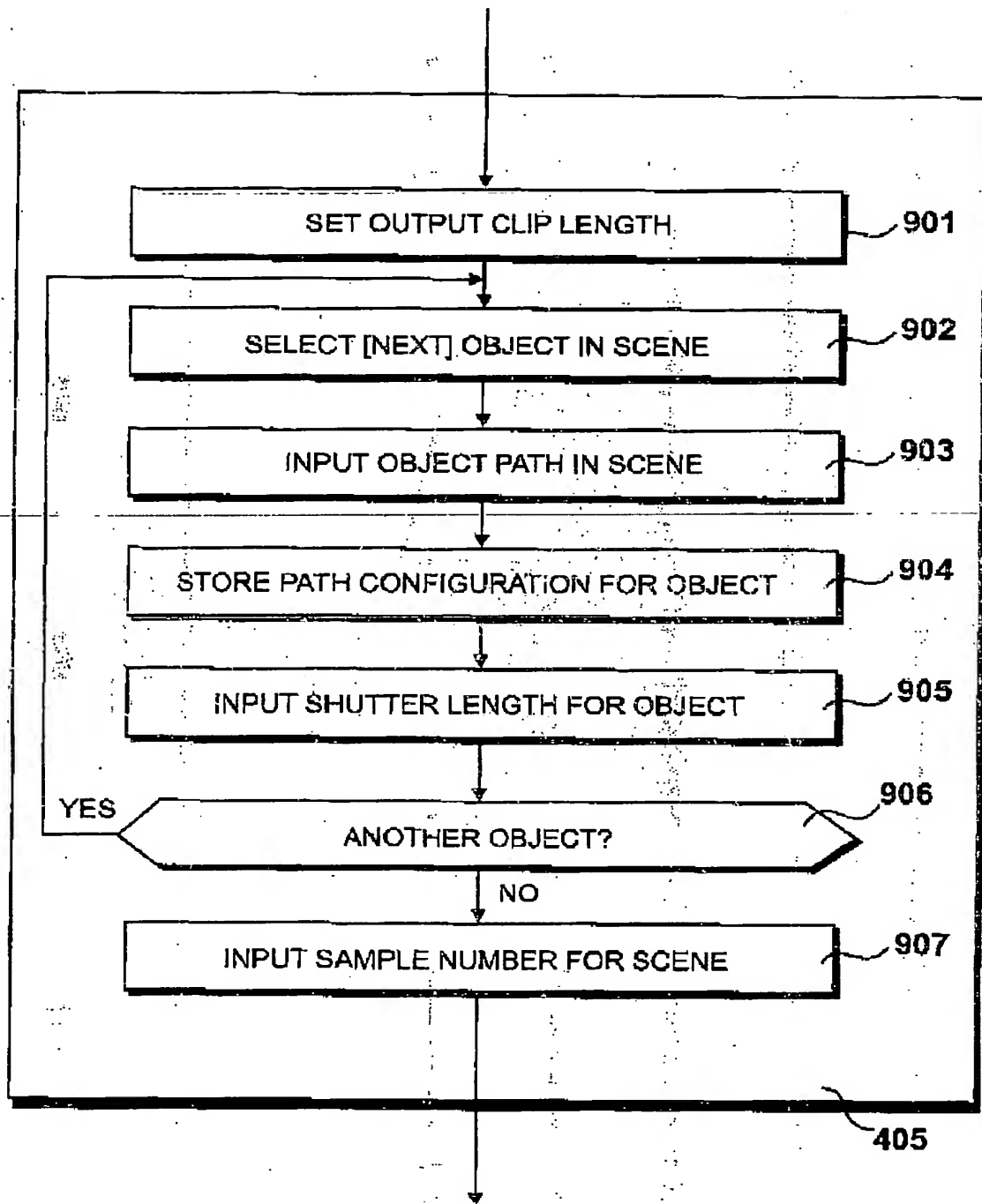


Figure 8

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*Figure 9*

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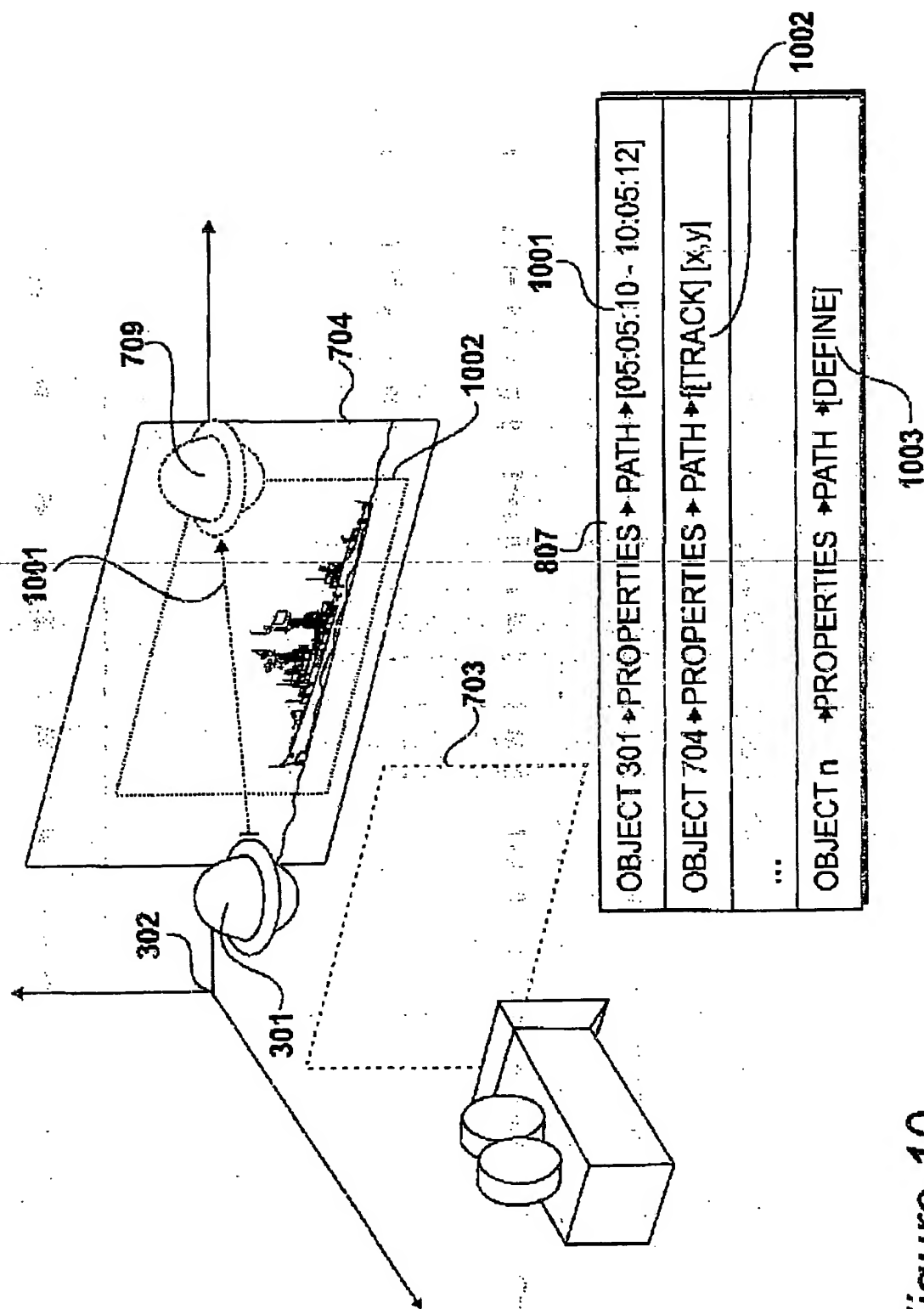
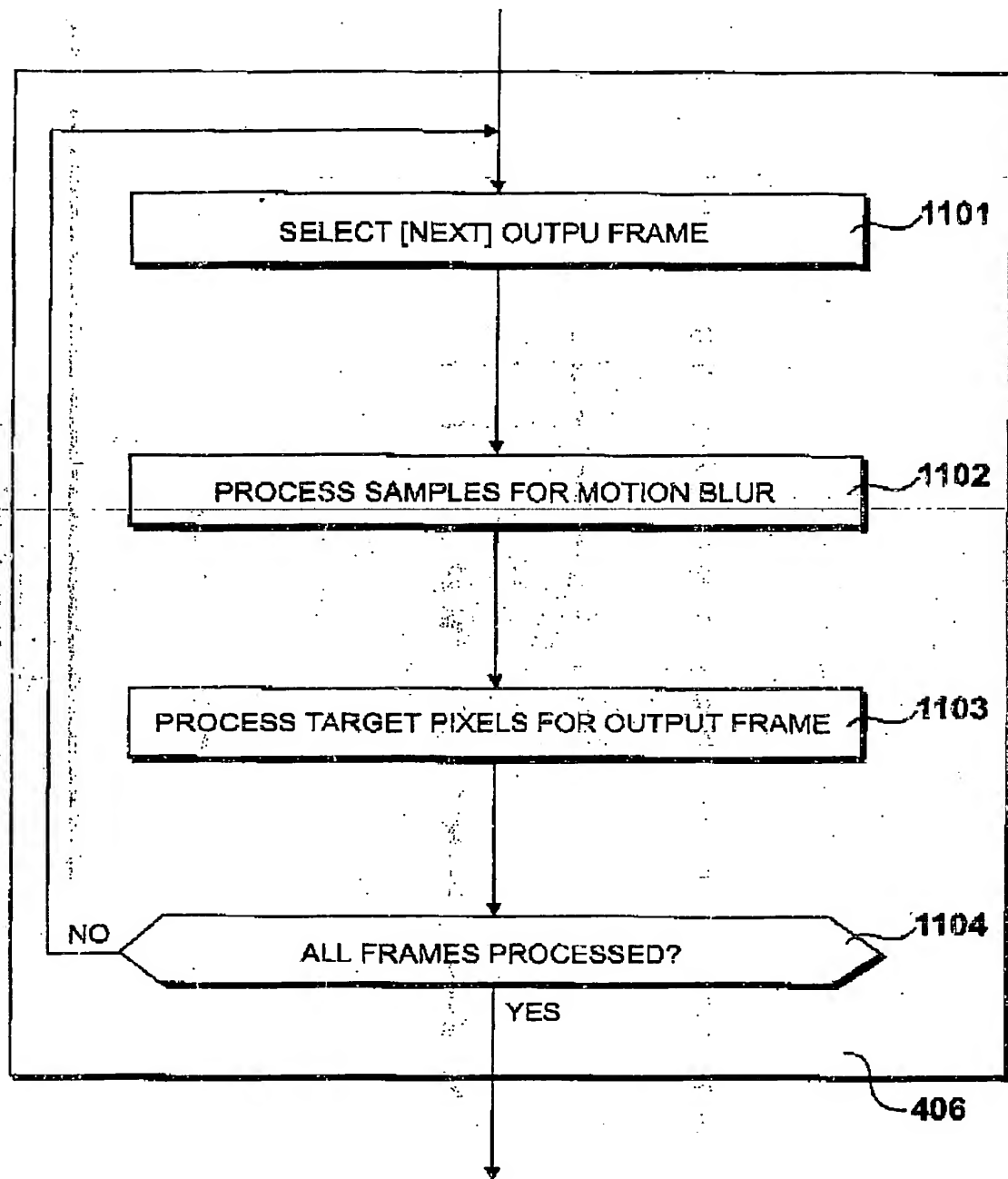


Figure 10

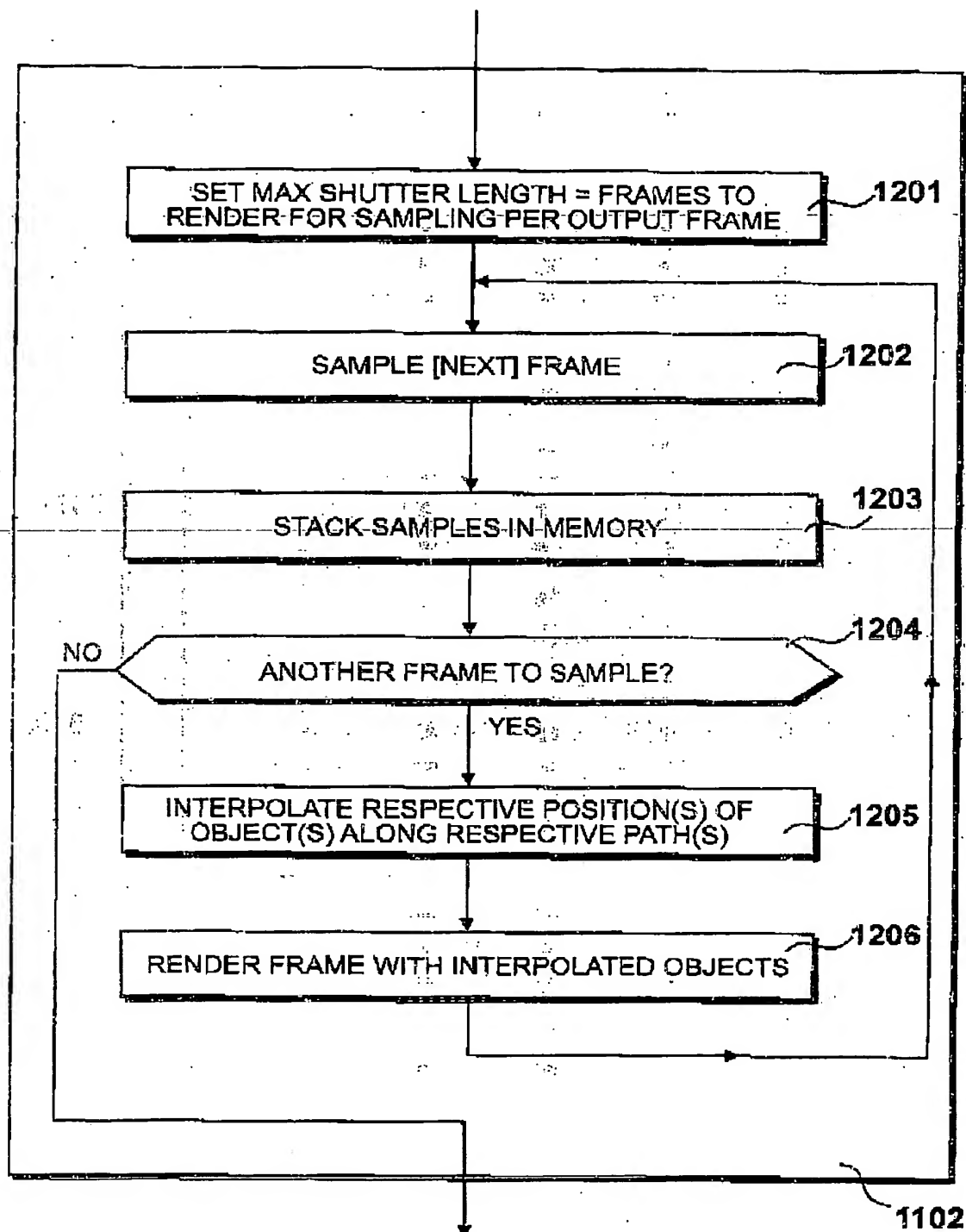
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*Figure 11*

2034-P585-GB

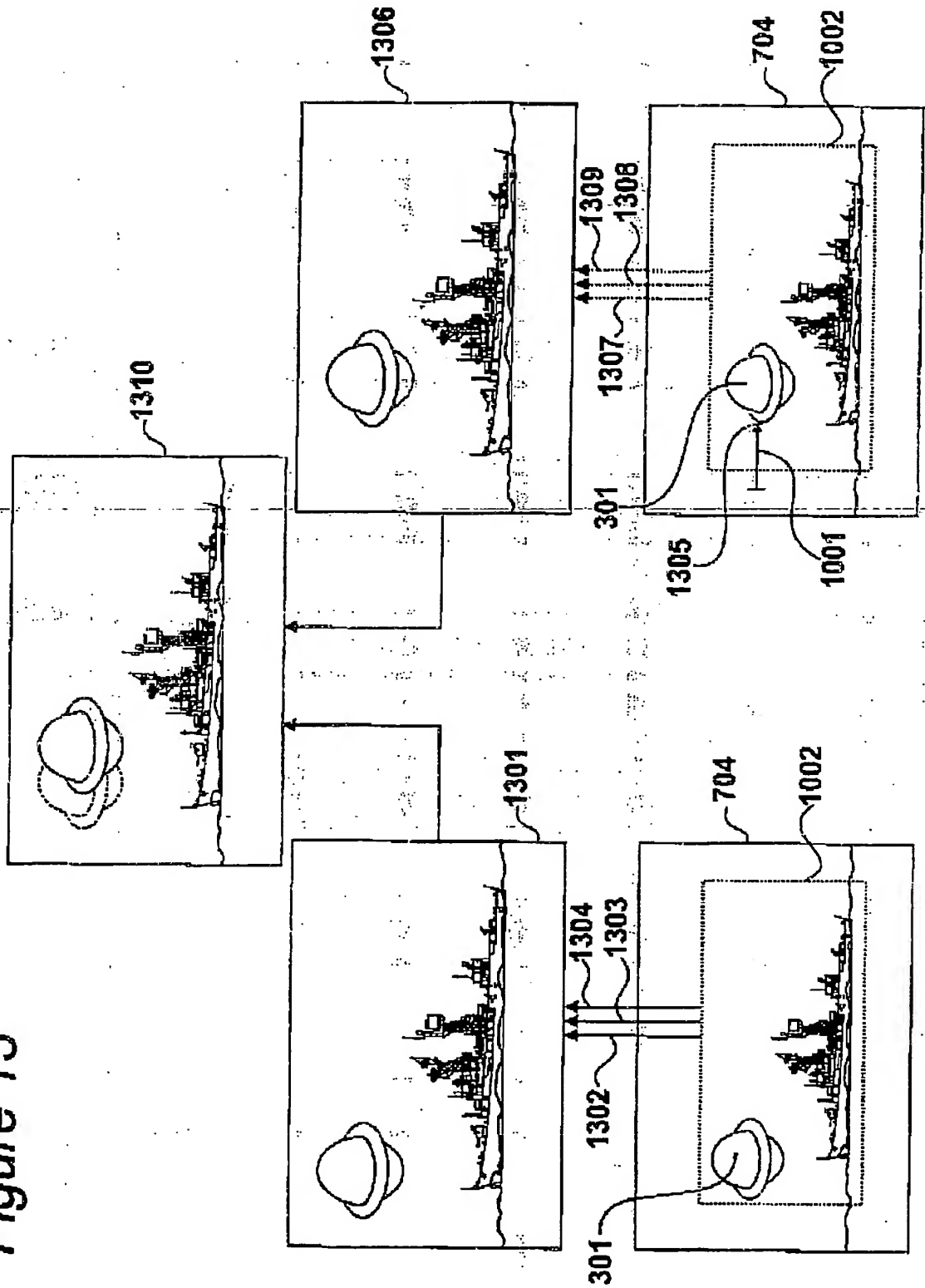
12/15

*Figure 12*

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13/15

Figure 13



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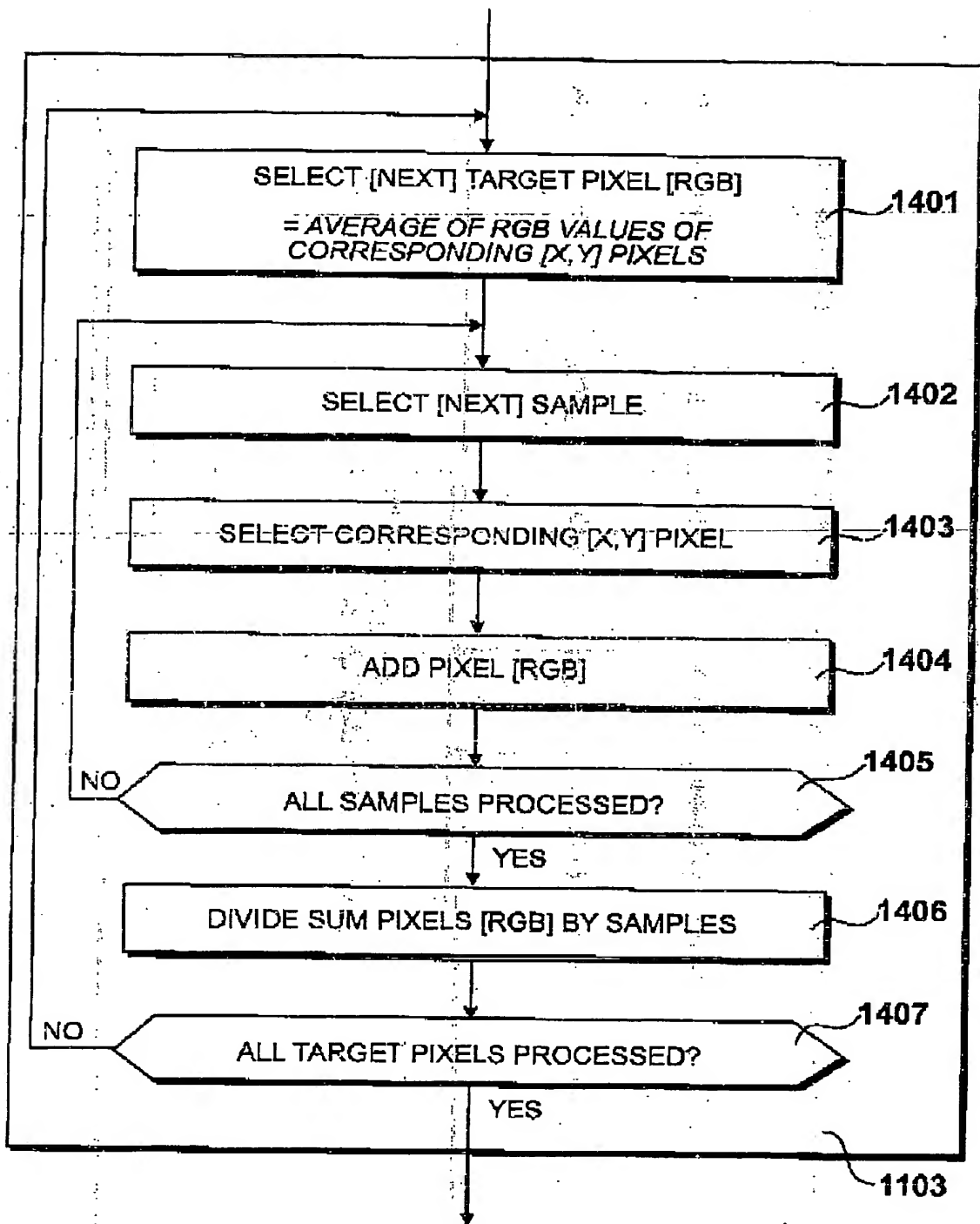


Figure 14

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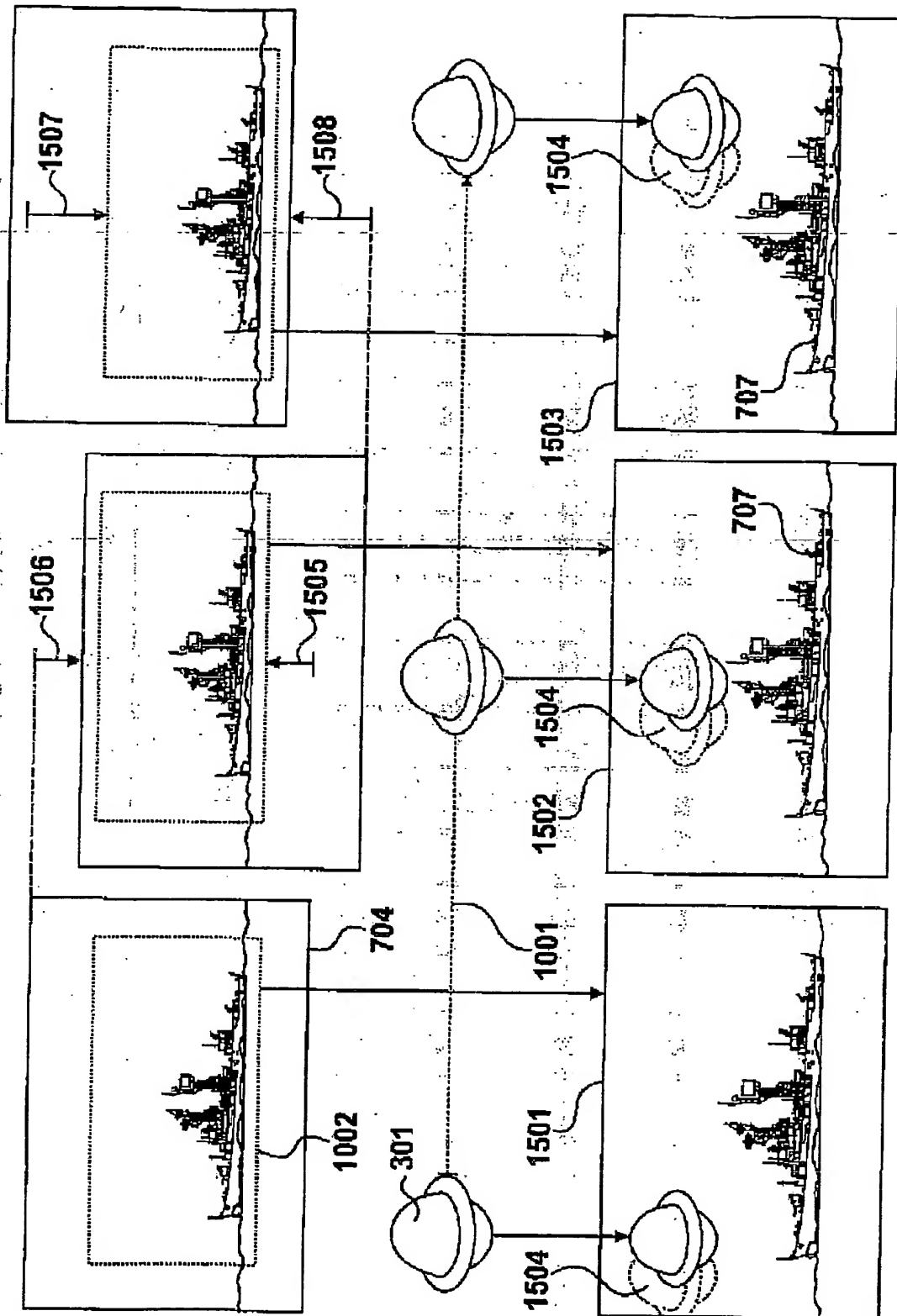


Figure 15

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